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Analyzing the Effects of Parameters on Alloy Steel during CNC Turning

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Abstract

One of the most common production procedures nowadays is turning. Chips are used to remove the metal. While the tool moves along the axis of rotation, the work item remains motionless (yet spins). To achieve efficient work, the CNC turning machine is regulated by a variety of process parameters and cutting circumstances. The goal of this research is to determine the relationship between process parameters and output parameters such as MRR and surface finish. Speed, feed, depth of cut, tool shape, coolant, and work material are some of the most frequent parameters that influence the processes. Analyzing these consequences also aids in the optimization of parameters for optimal performance. For solving such problems, a variety of strategies are available, with the Taguchi method being the most often utilised for optimization.

Keyword: *Alloy steel, CNC Turning, Taguchi Method, MRR, Surface roughness, MADM*

INTRODUCTION

The goal of modern companies is to produce high-quality products at a reasonable cost, which is why machining operations have become the backbone of the manufacturing industry. Computer numerical control (CNC), which uses computers to control the movement and operation of mills, lathes, and other cutting equipment, is utilised for a lot of modern machining. One of the production processes that can be managed by a computer is turning. Turning is a machining operation in which the work piece remains stationary while the tool moves along the work piece's axis of rotation. The effectiveness or the effectiveness parameters for input Several experimental investigations have been conducted over the years to investigate the effect of cutting settings and tool geometries on the surface integrity of work pieces utilising a variety of work pieces. Dimensional precision and surface polish are very important in today's manufacturing industry. Manufacturing businesses have relied on the use of handbook-based information to get optimal cutting parameters, which has resulted in a decline in productivity due to sub-optimal machining capabilities, resulting in high manufacturing costs and bad product quality [1].

As a result, the quality of the surface generated is a crucial factor to consider. In the turning process, vibration in the machine tool has a direct impact on the surface finish of the work material. As a result, one of the key variables limiting a machine tool's performance is vibration [2]. Similarly, several factors like as speed, feed, depth of cut, tool geometry, cutting force, coolant, and others affect the MRR and Surface roughness of the work piece directly or indirectly. Low carbon steel, sometimes known as mild steel, is a type of steel that contains 0.05 percent to 0.26 percent carbon and is widely used in technical applications (e.g. AISI 1018). They cannot be modified by heat treatment and are inexpensive, however because to their qualities, engineering applications are limited to non-critical Components. Because of its wide range of applications in sectors such as automobiles, structural steels, tool and die steels, and so on, the study is focused on alloy steel. Taguchi is the most extensively used optimization approach, according to a literature review. Similarly, there are a variety of methods for determining the impact of process factors on the machining operation's performance.

METHODOLOGY

The strategies used to solve optimization or performance analysis are listed below. The Taguchi approach is used by the majority of authors because it is simple to apply and produces effective results; however, some authors also employ techniques such as MADM, Gray rational analysis, and others.

Taguchi Method

Taguchi Method is a Japanese method of teaching. Taguchi design is one of the most powerful and convenient approaches for assessing experiments among all the methods available. Taguchi is most commonly employed in the development of new goods and in research and development.

Procedures for quality assurance the taguchi approach is used by the majority of researchers because of its advantages, such as its ease of use, efficiency, and methodical nature.

Relational Analysis in Grey

The impact of process parameters on other performances have not been considered when optimising responses in single objective optimization. However, in fact, all performance parameters must be tuned to reach the optimal result in order to create more productivity and more reliable goods. The grey relational coefficient was derived from the normalised experimental data to express the relationship between the desired and actual experimental data after the results were normalised.

MADM

MADM is a term used to describe a (Multi Attribute Decision Making). MADM is a well-known and strong analytical tool that may be used to help objectify decision-making in situations where there are multiple options or choices. Several possibilities are ranked and selected in MADM based on a set of criteria. Through decision-maker knowledge and expertise, a ranking and selection will be made among decision alternatives described by some criteria (factors). The well-known branch of decision making known as multi-attribute decision-making (MADM) deals with decision problems using a variety of qualitative and quantitative criteria [3].

REVIEW OF THE LITERATURE

Using CVD coated cemented carbide tools, Kaladhar M et al. investigated and discovered the optimal machining parameters in turning of AISI 202 austenitic stainless steel [4]. Process parameters such as speed, feed, depth of cut, and nose radius are used in the experiment. The most important criteria were Feed and Nose Radius, according to the findings. On AISI 304, Philip Selvaraj D et al. conducted an experiment and found that feed rate, cutting speed, and DOC all have a 51.84 percent, 41.99 percent, and 1.66 percent effect on surface roughness, respectively [5]. Turning carbon alloy steels at low feed rates and high spindle speeds, according to Satheesh Kumar N et al., produces a better surface polish [6]. SAE8620, EN8, EN19, EN24, and EN47 are five distinct carbon alloy steels used for turning. Using the Taguchi technique, Singh V et al. conducted an experiment and evaluated the effect and optimization of machining parameters on surface roughness and material removal rate (MRR) in a turning operation [8]. Cutting parameters such as cutting speed, feed rate, depth of cut, and cutting nose radius of insert are all varied in the experiments. The performance characteristics in the turning of AISI 1045 Mild steel utilising WNMG331RP, WNMG332RP, and WNMG333RP carbide inserts on a CNC turning centre were investigated using a L9 orthogonal array and the signal-to-noise (S/N) ratio. The findings demonstrated that the feed rate and nose radius were the most influencing parameters on surface roughness, and that the depth of cut, followed by cutting speed, has a significant impact on Material Removal Rate (MRR) in CNC turning processes. The depth of cut, followed by the nose radius, is the most important parameter affecting performance while simultaneously optimising Surface roughness (Ra) and material removal rate (MRR). The experiment by Kumar R et al. was conducted with various combinations of input parameter values [9]. All input parameters were given equal weighting, and a MADM (Multi attribute decision making) approach was applied. Speed, feed, and DOC were used as input parameters, and he discovered that Speed 1500 (rpm), Feed 0.12 (mm/rev.), D.O.C (mm) 1, and Nose radius at 1.2 are the ideal input parameters for cutting that will produce an efficient output. Rawat U et al. work in a dry environment, using the cutting force as the output parameter [10]. SS316L was employed as the work material. They discovered that the best spindle speed is 48 m/min, the best feed rate is 0.067 mm/rev, and the best cut depth is 0.75 mm. Aside from these studies, there have been a number of others conducted in the same topic in the past.

The Taguchi parameter design, as demonstrated by Sahu M et al., is a successful method for establishing the ideal cutting parameters for minimal tool wear, low w/p surface temperature, and high MRR [12]. They found that the percentage contributions of depth of cut (60.85%) and cutting speed (33.24%) in impacting tool wear variation are much higher than the contribution of feed rate (5.70 percent), Cutting speed and depth of cut contributed 41.17 percent and 34.45 percent, respectively, to w/p surface temperature, whereas depth of cut (51.1 percent) was the sole significant parameter on material removal rate, followed by feed (25.5 percent) (MRR). So, for maximal MRR, the ideal combination of cutting parameters was 250 m/min cutting speed, 1 mm depth of cut, and 0.25 mm/rev feed.

Table 1 Conclusions of Researchers by taking different Input and Output Parameters

No.	Year	Author's Name	Material	Input Parameters	Output Parameters	Conclusion
1	2010	M. Kaladhar, K. Venkata, Subbaiah, Ch. Srinivasa Rao, K. Narayana Rao	AISI202 austenitic stainless steel	Speed, Feed, DOC, Nose Radius	Surface Roughness	Feed and Nose Radius are the significant factors
2	2010	D. Philip Selvaraj, P. Chandramohan	AISI 304 Austenitic stainless steel	Speed, Feed, DOC	Surface Roughness	Concluded that feed rate, cutting speed and DOC affects the surface roughness by 51.84%, 41.99% and 1.66% respectively.
3	2012	N. Satheesh Kumar, Ajay Shetty, Ashay Shetty, Ananth K, Harsha Shetty	SAE8620, EN8, EN19, EN24, EN47	Spindle, Speed, Feed Rate	Surface Roughness	Better surface finish may be achieved by turning carbon alloy steels at low feed rate and high spindle speeds.
4	2013	J. M. Gadhiya, P. J. Patel	AISI 1018 Mild Steel	Speed, Feed, DOC	Surface Roughness	Cutting speed and feed have high contribution on surface roughness and Depth of cut had less effect for surface roughness.

5	2013	Virender Singh, Tasmeem Ahmad Khan	AISI 1045	Speed, Feed, DOC, Nose Radius	Surface roughness, MRR	MRR is greatly influenced By DOC followed by cutting speed, Feed is most significantly influences the Ra followed by nose radius Simultaneous optimization of (Ra) and (MRR), DOC is the most significant parameter affecting followed by the nose radius.
6	2013	Raman Kumar,	EN24	Speed,	Surface	Speed 1500 (rpm),
		Raman Kumar, Jaspreet Singh Rai, Navneet Singh Virk	alloy steel	Feed, DOC , Nose Radius	roughness, MRR	Feed 0.12 (mm/rev.), D.O.C (mm) 1 and Nose radius at 1.2 is the appropriate best input parameters setting.
7	2014	Umashankar Rawat, Mithun Shah, R. M. Patil	SS316L	Speed, Feed, DOC	Cutting Force	Optimum spindle speed, Feed rate and DOC are 48m/min, 0.067 mm/rev and 0.75mm resp.
8	2014	Shrikant S. Jachak, Vinay R. Pandey	AISI 1055 Steel	Speed, Feed, DOC, Cutting flow rate	Surface Roughness, Tool life	Adhesive bonded tool can be used for optimizing the turning process parameters
9	2014	Meenu Sahu, Komesh Sahu	AISI D2 Steel	Speed, Feed, DOC	Tool wear, w/p surface temperatur e, MRR.	Percent contributions of DOC (60.85%) and speed (33.24%) in affecting the tool wear. For w/p surface temperature cutting speed and DOC have contribution of 41.17% and 34.45% respectively. DOC (51.1%) and Feed (25.5%) on (MRR).

10	2014	Puneet Saini, Shanti Parkash, Devender Choudhary	EN-24 Alloy Steel	Speed, Feed, DOC	Surface Roughness	Surface roughness is mainly affected by feed rate and DOC. Cutting parameters for better quality Surface finish is as :- i) Spindle speed = 2800rpm. ii) Feed rate= 0.1 mm/min. iii) Depth of cut =0.5 mm.
11	2014	P. P. Shirpurkar, P. D. Kamble,	EN 24 steel	Speed, Feed, DOC,	Surface Roughness	Surface Roughness is most affected by nose radius (42.98%),
		S. R. Bobde, V. V. Patil		Nose Radius		cutting speed (29.37%) and feed rate (6.51%).
12	2014	Sushil Kumar Sharma, Sandeep Kumar	Mild Steel (1018)	Speed Feed DOC	Surface Roughness	Most significant parameters are Feed and Speed.
13	2015	Prajwal kumar Patil, Rajendrakumar Kadi Suresh Dundur, Anil Pol	AISI 316 Austenitic Stainless Steel	Speed, Feed, DOC	Surface Quality, Hardness	Feed has the highest influence on surface roughness. DOC has the highest influence on hardness. Optimal combination process parameters for minimum *Ra* is obtained at 150 rpm, 0.2 mm/rev and 1.5mm. The optimal process parameters for maximum hardness are 180 m/min cutting speed, 0.3 mm/rev feed, 1.5 mm DOC.

14	2015	Krupal Pawar, R. D. Palhade	HSS(M2)	Speed, Feed, DOC, Nose Radius	Surface Roughness, MRR	MRR is highly influenced by feed rate then nose radius. Ra is highly influenced by Nose radius then Feed. For both simultaneously most influencing parameter is nose radius
15	2015	A. H. A. Shah, A. I. Azmi, A. N. M. Khali	S45C Carbon Steel	Speed, Feed, DOC	Tool Wear, Surface Roughness, MRR	optimum parameter setting found in the current study are spindle speed of 3000 RPM and feed rate of 0.2 mm/rev.
16	2016	Abhishek Prakash	EN36C Steel	Speed, Feed, DOC	MRR, Surface Roughness	The feed has the greatest influence on MRR and Surface roughness
						Optimal conditional for MRR as the feed (0.1 rev/min) is a dominant parameter Speed (600 rpm) and depth of cut (0.1mm). Optimal condition for Surface roughness are depth of cut (0.1mm), feed (0.5 rev/min), and speed (900 rpm).

CONCLUSION

Almost every researcher, according to the above literature study, used speed, feed, and DOC as input parameters and Surface Roughness as an output parameter. A few studies have used nose radius as an input parameter and MRR as an output parameter. Because of its simplicity, the Taguchi approach was employed by the majority of the researchers to optimize the parameters. We discovered that feed is the most important element affecting the work piece's surface roughness, followed by nose radius and speed. The depth of cut is the most important component for MRR, followed by speed. DOC has the biggest impact on tool wear and surface temperature, while other parameters have the least impact.

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